ASSESSMENT OF MARINER 10 STEREO IMAGES OF MERCURY; A. C. Cook[1], M. S. Robinson[2], and J. Oberst[1]; [1]DLR, Institute of Planetary Exploration, Rudower Chausee 5, D-12489 Berlin, Germany (Email: cook@terra.pe.ba.dlr.de); [2]U.S. Geological Survey, 2255 N. Gemini, Dr., Flagstaff, AZ, 86001 (Email: robinson@flagmail.wr.usgs.gov).

Introduction: Mariner 10 flew by Mercury three times in 1974-75, each time following a different trajectory and thus viewing Mercury from unique perspectives [1]. More than 2300 images were obtained. Unfortunately for areal coverage the subsolar point was nearly identical at each flyby, however this is a great advantage for stereo analysis as shadows and topographic shading are nearly the same for each encounter. We have completed an assessment of the number and quality of stereo pairs included in the Mariner 10 image set of Mercury. Furthermore, we have conducted a pilot study in which we tested procedures for the derivation of Digital Elevation Models (DEMs).

Method and Results: We performed a search amongst 793 images from the control net of Davies et al. [2] following methods described in [3] and using specific search criteria which were based upon experience with digital analysis of stereo imagery: 1) limb images were excluded, 2) wide angle images were excluded, 3) for a stereo pair, any permutation of camera A/B and filters were allowed, 4) images with worse than 3km resolution (IFOV size) were excluded, 5) maximum permitted resolution ratio in a stereo pair was 3x, 6) images where the Sun was < 5° above horizon were excluded, 7) images for which the spacecraft was < 25° above the horizon were excluded, 8) permitted base to height ratio was between 0.02 and 3.0, 9) height accuracy was better than 2 km (height accuracy = (maximum pixel size/base-to-height ratio)).

Using these conservative selection criteria, we found approximately 500 images suitable for stereo analysis. These stereo images cover 17% of the surface of Mercury with a stereo height accuracy better than 2km. Some 12.5% of the surface is covered at better than 1km, about 8% better than 500m, and 3% better than 300m (see Fig. 1). Height accuracies were estimated on the assumption that, for Mariner 10 vidicon images, one can only measure relative pixel positions in the image planes to 1 pixel accuracy.

We tested the feasibility of extracting accurate topographic data from Mariner 10 data by processing three overlapping stereo images (Fig. 2) based upon methods described by [4]. A crucial element in the processing is digital stereo image matching. Initial matched results are excellent and show that topographic features in the DEM resemble those in the imagery, and that the stereo height accuracy agrees generally with the predictions of the map. However, we found that due to the severe degradation of image quality, caused by "salt and pepper" noise inherent in most frames, care must be taken to process each image on an individual basis. We have utilized an iterative noise removal algorithm first presented in [5] and find that the analyst must make a judgment on the severity of the noise and pick program parameters accordingly, otherwise too much smoothing can occur and the matcher algorithm becomes less efficient. Additionally, we have found that the location of each of the 111 reseaus in an image must be checked by hand after the automated "finder" routine has completed. The severe "salt and pepper" noise sometimes results in misidentified reseaus and these can cause topographic distortions in the DEM.

Future Prospects: The only other topographic data available for Mercury are the sparse coverage provided by Earth- based radar profiles [6]. Very little analysis of Mariner 10 stereo images obtained in the seventies has been done. Only recently, have sophisticated filtering and geometric recalibration been applied to the Mariner data [7], and new orbit and camera pointing data reconstructions [8] been performed. Furthermore, advanced methods and tools for photogrammetric analysis and extraction of DEMs from digital stereo images exist which were not available in the past. Thus, the Mariner stereo data are now ripe for analysis. Digital terrain data for Mercury would be invaluable for investigating first order geologic questions such as basin identification, cratering mechanics, global tectonic history, and volcanic material emplacement mechanisms. Additionally, these data would prove helpful for planning any future missions to Mercury, be they orbital or lander. Finally, a DEM would provide a baseline control for higher spatial resolution photoclinometric studies [9].

References: [1] M.E. Davies et al., Atlas of Mercury, (1976), NASA SP-423. [2] M.E. Davies et al., (1976), RAND Publication R-20290-NASA. [3] A.C. Cook et al., (1996), Planet. Space Sci., 44,1135-1148. [4] J. Oberst et al., (1996) Planet. Space Sci., 44,1123-1133. [5] E. Eliason, and A.S. McEwen, (1990), Photogram. Eng. and Remote Sensing, 56,453,. [6] J.K. Harmon and D.B. Campbell, (1988), in Mercury, Univ. of AZ Press, 101. [7] M.S. Robinson et al., this volume. [8] M.E. Davies et al., (1996), Bull. Am. Ast. Soc., 28,1115. [9] T.R. Watters et al, this volume.

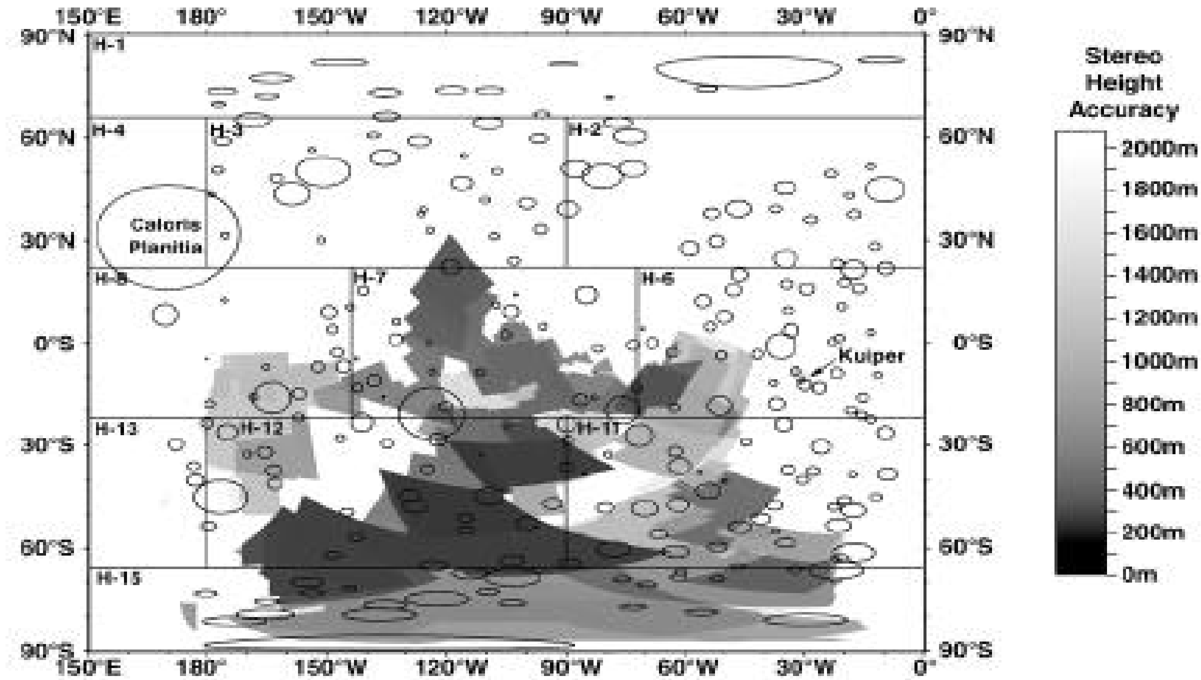

Fig. 1. Stereo height accuracy map of Mariner 10 images of Mercury (simple cylindrical projection). Dark shadings represent good stereo height accuracy; progressively lighter shadings indicate poorer stereo accuracy, and white indicates no stereo coverage using our criteria. Outlines of named craters, and 1:5M USGS shaded relief maps, are illustrated.

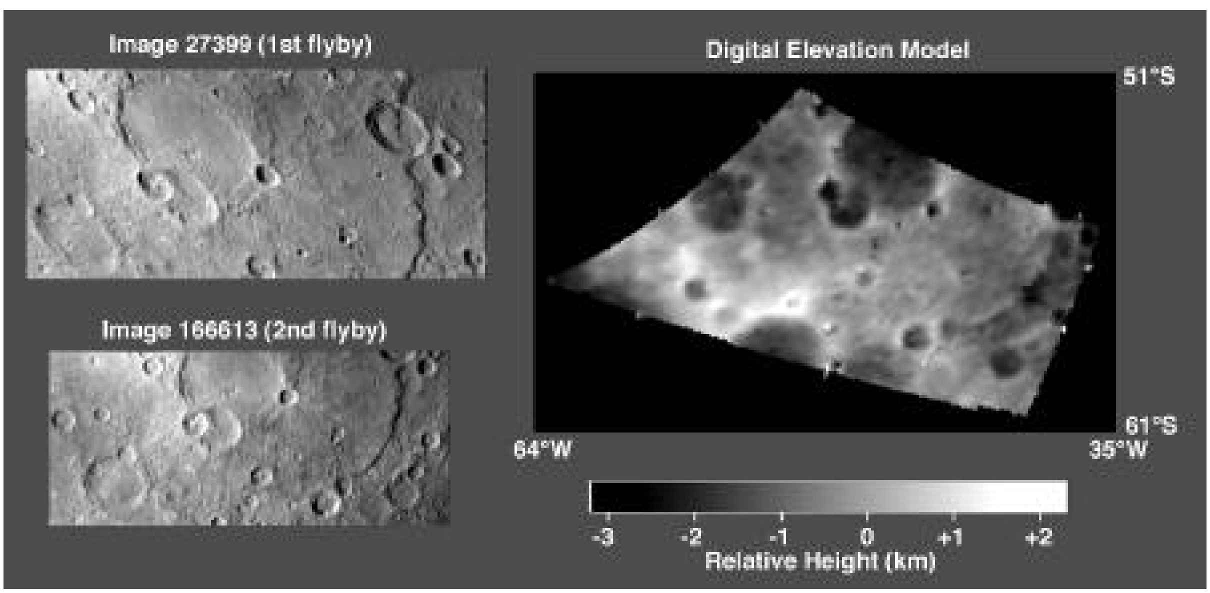

Fig. 2. Example of a Digital Elevation Model (DEM) (see also [8]) from the stereo overlap between Mariner 10 images: 027398, 027399, 166613. Dark is low, and white is high. Sub-sections of two of the original images are shown on the left.